

FORM PTO-1390 (Modified)  
(REV 11-98)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER

RCA 89855

**TRANSMITTAL LETTER TO THE UNITED STATES  
DESIGNATED/ELECTED OFFICE (DO/EO/US)  
CONCERNING A FILING UNDER 35 U.S.C. 371**

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR

**09/869492**

INTERNATIONAL APPLICATION NO.  
PCT/US99/29939

INTERNATIONAL FILING DATE

15December1999(15.12.99)

PRIORITY DATE CLAIMED

11January1999(11.01.99)

TITLE OF INVENTION

A STEREOPHONIC SPATIAL EXPANSION CIRCUIT WITH TONAL COMPENSATION  
AND ACTIVE MATRIXING

APPLICANT(S) FOR DO/EO/US

Alan Anderson Hoover

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
  - a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ☒ has been transmitted by the International Bureau.
  - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ A copy of the International Search Report (PCT/ISA/210). attached to Item 13
8. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
  - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ☐ have been transmitted by the International Bureau.
  - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
  - d. ☒ have not been made and will not be made.
9. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
10. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
11. ☒ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

Items 13 to 20 below concern document(s) or information included:

13. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98. with references attached
14. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☒ A **FIRST** preliminary amendment.
16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
17. ☐ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☒ Certificate of Mailing by Express Mail
20. Return postcard receipt

~~Other items or information:~~

**CERTIFICATE OF MAILING UNDER 37 CFR 1.10**

EL685391368US

June 28, 2001

"Express Mail" mailing no.

Date of Deposit

I hereby certify that this application is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231.

Davida Fornarotto  
Typed or printed name of person  
mailing application

Davida Fornarotto  
Signature of person mailing  
application

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR

09/869492

INTERNATIONAL APPLICATION NO.

PCT/US99/29939

ATTORNEY'S DOCKET NUMBER

RCA 89855

21. The following fees are submitted:

**BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :**

- ☐ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO .....\$1000.00
- ☒ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO .....\$860.00
- ☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO .....\$710.00
- ☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) .....\$690.00
- ☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) ..... \$100.00

**ENTER APPROPRIATE BASIC FEE AMOUNT =**

**CALCULATIONS PTO USE ONLY**

860.00

Surcharge of \$130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE
Total claims	14 - 20 =	0	x \$18.00
Independent claims	2 - 3 =	0	x \$80.00
Multiple Dependent Claims (check if applicable).			<input type="checkbox"/>

**TOTAL OF ABOVE CALCULATIONS = 860.00**

Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28) (check if applicable). ☐

**SUBTOTAL = 860.00**

Processing fee of \$130.00 for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)).

**TOTAL NATIONAL FEE = 860.00**

Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) (check if applicable). ☐

40.00

**TOTAL FEES ENCLOSED = 900.00**

Amount to be: refunded	\$
charged	\$ 900.00

- ☐ A check in the amount of \_\_\_\_\_ to cover the above fees is enclosed.
- ☒ Please charge my Deposit Account No. 07-0832 in the amount of \$900.00 to cover the above fees. A duplicate copy of this sheet is enclosed.
- ☒ The Commissioner is hereby authorized to charge any fees which may be required, or credit any overpayment to Deposit Account No. 07-0832 A duplicate copy of this sheet is enclosed.

**NOTE:** Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

**SEND ALL CORRESPONDENCE TO:**

Mr. Joseph S. Tripoli  
THOMSON multimedia Licensing Inc.  
Patent Department  
PO Box 5312  
Princeton, New Jersey 08540

SIGNATURE

Frederick A. Wein  
NAME

27,168

REGISTRATION NUMBER

June 28, 2001

DATE

RECEIVED JUN 28 2001

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : Alan Anderson Hoover  
Filed : Herewith  
For : A STEREOPHONIC SPATIAL EXPANSION CIRCUIT  
WITH TONAL COMPENSATION AND ACTIVE  
MATRIXING

PRELIMINARY AMENDMENT

Hon. Commissioner of Patents and Trademarks  
Box PCT  
Washington, D.C. 20231

Sir:

In the US national phase application of PCT/US99/29939 filed  
herewith, please enter the following amendments:

IN THE SPECIFICATION:

Please amend the specification as follows: A marked up version of the  
amended specification is attached herewith:

On Page 1, line 6, after "January 11, 1999" insert the following:

-- which is hereby incorporated herein by reference, and which claims  
the benefit under 35 U.S.C. § 365 of International Application PCT/US99/29939,  
filed December 15, 1999, which was published in accordance with PCT Article 21(2)  
on July 20, 2000 in English.--

IN THE ABSTRACT:

Please add the following Abstract.

-- In a stereophonic expansion circuit, the (L+R) sum signal is  
spectrally modified by increasing the bass and treble frequencies relative to the  
midrange so as to compensate for a midrange frequency boost in the (L-R) difference  
signal. The stereophonic expansion effect and manipulation of the signal parameters  
are produced by active matrixing amplifiers.--

## REMARKS

The specification has been amended to include a reference to the priority applications.

To meet the requirements of the United States, the Abstract (as originally filed in the PCT application) is added.

No fee is believed to have been incurred by virtue of this amendment. However if a fee is incurred on the basis of this amendment, please charge such fee against deposit account 07-0832

Respectfully submitted,  
Alan Anderson Hoover



Frederick A. Wein  
Attorney for Applicant  
Registration No. 27,168  
609/734-9518

THOMSON multimedia Licensing Inc.  
Patent Operation  
PO Box 5312  
Princeton, NJ 08543-5312

June 28, 2001

MARKED UP VERSION OF THE AMENDED SPECIFICATION

Please amend the specification as follows: A marked up version of the amended specification is attached herewith:

On Page 1, line 6, after "January 11, 1999" insert the following:

-- which is hereby incorporated herein by reference, and which claims the benefit under 35 U.S.C. § 365 of International Application PCT/US99/29939, filed December 15, 1999, which was published in accordance with PCT Article 21(2) on July 20, 2000 in English.--

PTO/PGT Rec'd 28 JUN 2001

**A STEREOPHONIC SPATIAL EXPANSION CIRCUIT WITH TONAL  
COMPENSATION AND ACTIVE MATRIXING**

**CLAIM OF PRIORITY**

5                   A right of priority is claimed from United States provisional patent application No. 60/115,324, filed January 11, 1999.

**FIELD OF THE INVENTION**

10                   The present invention relates to a television receiver for receiving television program signals which include stereophonic sound signals, and, more particularly, to the generation of a psychoacoustic stereophonic expansion effect so that it acoustically appears to the listener that the spatial separation of the loudspeakers is greater than the actual physical separation.

15                   **BACKGROUND**

20                   Stereo expansion in audio systems is well known in the art and has been available for many years. In such systems, the right and left channel signals are processed in a manner wherein psychoacoustic effects makes it acoustically appear to the listener that the spatial separation of the loudspeakers is greater than the actual physical separation. Stereo expansion is described in, inter alia, U.S. Patent Nos. 4,495,637 of Bruney, 4,831,652 of Anderson et al., 5,208,493 of Lendaro et al., and 5,850,453 of Klayman et al., and e.g., was used in the RCA CTC 169 color television chassis of Thomson Consumer Electronics Inc., U.S.A.

25                   An exemplary prior art stereo expansion circuit is shown in Fig. 1, wherein stereo expansion circuit 10 includes two operational amplifiers (opamps) 11 and 12. A left (L) channel signal is applied to the positive (non-inverting) input terminal of opamp 11 by way of an input line 13. A portion of the right (R) stereo channel is cross-fed to the left (L) channel opamp 11 at the inverting input terminal thereof. A similarly processed inverted portion of the left channel is cross-fed to the right channel opamp 12 at the inverting input terminal thereof.

30

35                   Again referring to Fig. 1, the right and left channel signals are fed back by the respective resistors 16 and 19. The cross-channel cross-fed signals cause each channel's output to effect the output of the other channel. Specifically, because of the cross-feeding, the output signal on the left output line 15 of the opamp 11 is a  $L + X(L-R)$  signal while the output signal on the right output line 18 of the opamp 12 is a  $R + X(R-L)$  signal with the coefficient "X"

being determined by the characteristics of the filter 22, and typically is between the values of one and two.

Filter 22 of the cross-feeding circuit includes a capacitor 24 and a resistor 25 which determine the crossover frequency at which cross-feeding occurs, i.e., very little coupling between channels at low frequencies, increased coupling as the frequency increases from about 150 Hz or 200 Hz, and full coupling at about 1 KHz to 3 KHz. The parallel combinations of resistor 16 and capacitor 27L, and resistor 19 and capacitor 27R, roll-off the frequency response of amplifiers 11 and 12 respectively to decrease the coupling between the channels through transmission gate 21 to virtually zero above 5 KHz. For the circuit of Figure 1, the upper frequency break point for an exemplary channel is  $F_u = 1/(2\pi(\text{capacitor } 27)(\text{resistor } 19))$  and the lower frequency break point is  $F_l = 1/(2\pi(\text{capacitor } 24)(\text{resistor } 25))$ . The frequency vs. amplitude response of the prior art circuit of Fig. 1 for a single channel input signal is shown in Fig. 2.

The bandlimiting of the crossfed signal to the midrange frequencies for the circuit shown in Fig. 1 often causes two undesirable artifacts of the perceived sound:

1. The overall sound tonality seems to have an increased midrange boost (Fig. 2) while the perceived center-stage image and tonality remain unchanged. Thus, the new perceived sound source, apparently located physically outside the stereo speaker pair locations, has a distinct midrange quality which appears in addition to the existing perceived image near center stage. If the listener moves to an off-axis location where the perceived stereo image deteriorates, the adding of the "expanded stereo" is heard as a midrange increase.

2. The midrange expanded-image program material can "drown out" a center stage performer particularly when the program material has a high content of difference signal (L-R) relative to sum signal (L + R) material.

## **SUMMARY OF THE INVENTION**

The present invention is intended to solve the problem of the undesirable artifacts discussed above in the perceived sound that often occur as a result of the "expanded stereo" function while still preserving the perception of an expanded stereo image.

In order that low frequency program material (bass) not be reduced in amplitude, the (L-R) gain increase is usually confined to the midrange portion of the audio spectrum. The reason for this is that bass program material is often

mixed monaurally so that both loudspeakers will share the duty equally in reproducing bass, which requires the most acoustic power to be produced by the power amplifiers and the loudspeakers. This does not detract from the psychoacoustic phenomenon of stereo imaging, because most imaging comes from phase and amplitude differences in the mid-frequency range of audio that reaches the ears from both loudspeakers. This phenomenon has been widely studied and has been documented in many publications.

The present invention spectrally modifies the stereo sum signal by increasing the bass and treble frequencies of the signal relative to the midrange. The spectral modification is approximately complementary to the midrange frequency boost of the difference signal, which is used to produce the expanded stereo effect so as to provide a flatter frequency response to the total signal.

The subjective impression that is created as a result of these modifications are:

1. The addition of bass and treble boost to the (L+R) signal restores tonal balance to the overall signal that is lost when the (L-R) signal is boosted in the mid-frequency range.

2. The addition of treble to the (L+R) signal adds intelligibility to center-stage vocalists by making spoken sounds louder. The "drowned-out" center-stage vocalist problem is eliminated or reduced.

For a stereo image expansion circuit, the amount of expansion that is perceived is proportional to the amount of the midrange difference signal relative to the sum signal. This could be the amount of (L-R) midrange signal that is boosted relative to the (L+R) signal. There is no "exact" amount of difference signal midrange boost relative to sum signal that is "correct" and it is largely a matter of listener preference. The exact frequency band that is boosted is also not of critical importance, although if the midrange frequency is allowed to become too low in frequency, bass loss will be noticed, if the midrange frequency is allowed to become too high in frequency, an unstable image that appears to wander will be noticed, and if the crossfed frequency band is too narrow, the expansion will not seem realistic due to excessive tonal difference between the expanded and center portions of the stereo image.

The (L+R) and (L-R) signals can be derived from stereo detection of a stereophonic broadcast, or from left and right signals which are provided by a signal source, e.g., phonograph record, tape, CD or DVD disk, which are active matrixed to provide (L+R) and (L-R) signals in order to provide the spatial expansion effect. As used herein, active matrixing means active amplifiers having predetermined gain, which are coupled in a matrixing configuration.



**BRIEF DESCRIPTION OF THE DRAWINGS**

Fig. 1 is a schematic diagram showing a prior art stereo expansion circuit which has been already discussed hereinabove.

Fig. 2 is a graph of frequency vs. amplitude of the circuit of Fig. 1 and has been already discussed hereinabove.

Fig. 3 is a schematic diagram of an (L+R) circuit with tonal compensation according to aspects of the present invention.

Fig. 4 is a graph of frequency vs. amplitude for the circuit of Fig. 3.

Fig. 5 is a schematic diagram of a stereophonic expansion circuit according to aspects of the present invention, using active matrixing, providing the stereophonic expansion effect and including tonal compensation.

**DESCRIPTION OF THE PREFERRED EMBODIMENT(S)**

Figure 3 shows the (L + R) signal path modified according to aspects of the present invention to restore tonal balance to the expansion function. This circuit includes a switch for switching the tonal compensation "in" and "out" by the application or the stopping of base current to transistor 32 through resistor 34. By connecting the terminal of 34 to a dc supply of approximately 5 to 15 volts, transistor 32 is turned "on" (saturated). This grounds the ground terminals of 36, 38, and 40 which are all connected to the collector electrode of transistor 32. In this mode, the circuit has the frequency response shown in Figure 4. If the base resistor 34 is grounded, then transistor 32 is turned "off" and amplifier 42 is effectively a unity gain follower with a flat frequency response. Normally, the placement of transistor 32 into saturation would be accomplished by a control signal actuated by the end user, and would be implemented under microprocessor control (not shown) of the television signal receiver, sound system, or the like.

Taking the time constants of Fig. 3 in order from lowest frequency to highest frequency, and taking transistor 32 as being in saturation; as follows:

The RC time constant which takes effect at the lowest frequency is resistor 39/capacitor 40 (47K, 1uF, respectively). Amplifier 42 is effectively a unity gain inverter from 0 Hz to about 3.4 Hz, where the resistance value of resistor 39 equals the impedance of capacitor 40. Above 3.4 Hz, the voltage gain of amplifier 42 approaches two, which is determined by resistors (46 + 39)/39. For audible frequencies, the gain of amplifier 42 can be considered to be 2 or higher.

Resistors (35 + 48)/capacitor 36 (47K, 100K, .0075uF, respectively) form a lowpass filter having a first breakpoint of 3dB down at 144 Hz. As the signal frequency increases, the voltage divider formed by resistors 48 and 46 determines the final signal gain of amplifier 42. The final attenuation is resistor 35/(resistors 35 + 48), or -9dB. Thus, from the subaudible frequency of 3.4 Hz, the overall system gain is about 6 dB, until the resistors (35 + 48)/capacitor 36 lowpass filter starts to reduce the overall system gain in the 100 to 200 Hz range.

At a frequency of about 2 KHz, the reactance of capacitor 38 (.0022 uF) plus resistor 37 equals the resistance of resistor 39. At this frequency, the voltage gain of amplifier 42 starts to increase above two because the series network impedance of resistor 37 and capacitor 38 starts to dominate the impedance between the negative input terminal of amplifier 42 and ground. This gain increase offsets the attenuation of divider resistor 35/resistors (48 + 35). At a frequency of about 6.6 KHz, the reactance of capacitor 38 equals resistor 37 and the gain of amplifier 42 starts to level off, approaching a final value of about +6dB.

Fig. 4 is a graph showing the gain vs frequency characteristics of the circuit of Fig. 3, as discussed above.

#### FIGURE 5

The tonal compensation circuit of Fig. 3 for the (L+R) signal is included in the spatial stereophonic expansion circuit shown in Fig. 5 wherein the stereophonic expansion is accomplished by processing the (L+R) and (L-R) signals. After spatial stereophonic expansion, the L and R signals with tonal compensation are derived from the modified (L+R) and (L-R) signals by active matrixing.

Reference will now be made to Fig. 5, wherein the present invention achieves stereo image expansion, sum signal tonal restoration, and active amplifier signal matrixing, as follows:

Generally, as an overview, if the signal is derived from a source which provides left and right signals, difference and sum circuits are utilized to combine the left and right stereo channel signals into difference (L-R) and sum (L+R) signals by active amplifier matrixing. Filter and gain circuits are used to tonally compensate the (L+R) signal so that it is boosted in the bass and treble frequencies, as discussed above in connection with Fig. 3 and shown in Fig. 4. Filter and gain circuits are used to modify the (L-R) signal so that it is boosted in the midrange frequencies and provides the spatial expansion effect. The

modified (L-R) and (L+R) signals are then matrixed back into modified left and modified right signals, using difference and sum active amplifier matrixing. The tonally compensated (L+R), (L-R), R and L signals are available for further processing, as desired.

5 For the purposes of the discussion below:

1) Bias resistors and coupling capacitors are not discussed or numerically designated but are only shown for completeness.

2) Where the values of resistors are used for matrixing, the designation XR is used to indicate the equal values between that resistor R and a corresponding matrixing resistor R having the same numeral designation. Thus, the numeral designator is used to distinguish between different R resistor sets which can have greatly differing values.

3) Where the components have been discussed above in connection with Fig. 3, identical numeral designations are used.

15 4) No differentiation is made as to whether the signals at the nodes have been modified as to tonality. The nodal designations of signals are intended to demonstrate the matrixing function. Thus, e.g., if a signal at a node is shown as divided by two, the halving is accomplished by the matrixing function as determined by the matrixing resistors and matrixing amplifiers.

#### 20 (L+R) SIGNAL PATH

Left and Right stereophonic inputs are summed through equal resistors symbolically designated 1R, forming an (L+R) sum signal at the base of emitter follower transistor 50 having approximately unity gain. The values of bias resistors have sufficiently high values so as not to significantly load the (L+R) sum signal. The (L+R) signal is applied to the non-inverting input of opamp 42.

Passive resistors 35, 37, 39, and capacitors 36, 38, 40 alter the spectral response of the buffered (L+R) signal, as discussed above in connection with Fig. 3 and shown in Fig. 4. When transistor 32 is placed in a non-conducting state, passive components resistors 35, 37, 39, and capacitors 36, 38, 40 have no effect on the buffered (L+R) signal and opamp 42 functions as a non-inverting amplifier with a gain set by resistors  $(46 + 52)/52$ , or approximately 2:1.

#### 35 (L-R) SIGNAL PATH

The right channel input is coupled through resistors 2R to an inverting input of opamp 54 to become -R at the output. Lin and -Rin are

summed by respective further resistors 3R to form the (L-R) signal at node 63 and noninverting input of opamp 56. Opamp 56 is a noninverting gain amplifier when an expansion function, which will be discussed hereinbelow, is "off" because resistors 60, 64 and capacitors 58, 62 are effectively out of the circuit when transistor 66 is cut-off with its base connected to -V by selector switch 68 through resistor 34a. The same discussion above in connection with switch 68 and transistor 32 are applicable hereat when transistor 66 goes into saturation and components 58, 60, 62 and 64 come into play.

For the following discussion, boost transistor 70 is assumed to be in the off state, with boost switch 72 connected to an appropriate negative voltage by being placed in the "out" position. Transistors 32 and 66 are placed into a saturated state by placing switch 68 to the "in" position. Since the collector of transistor 66 is effectively grounded in this condition, the node which connects the collector of transistor 66 is effectively grounded.

Transistors 70 and 71 provide an expansion "boost". When transistors 70,71 are placed into saturation by boost switch 72 via base resistors 82, 82a, an additional gain boost is placed in the feedback loop of opamps 56, 42 by placing respective resistors 72, 75 in series with resistors 74, 46, with both in parallel with respective resistors 78, 52. The boost of the (L+R) signal and the (L-R) signal may or may not be the same. Thus, this can provide a few more dB of gain to the (L-R) signal path with respect to the (L+R) signal path for providing the desired amount of expansion effect.

It should be noted that switching transistors 32, 66, 70 and 71 can be field effect transistors, mechanical switches, or the like.

Feedback resistors 72 and 74 have preferred values of 1K and 100K, respectively. At very low audio frequencies, the gain of opamp 56 is set by resistors 72 and 74 in series, and resistor 78, because the reactance of capacitor 62 is very high. The gain is approximately two (6dB) at low audio frequencies. A similar operation applies to opamp 42 in connection with resistors 75, 46 capacitor 38, and transistor 71.

The reactance of capacitor 62 (preferably 0.056uF) is 100K ohms at a frequency of approximately 28 Hz. At this breakpoint frequency, the reactance of capacitor 62 equals the sum of resistors 72 and 74. The gain of opamp 56 starts to rise. The opamp 56 gain rises until the reactance of capacitor 62 equals the resistance of resistor 64 (24K). The gain of opamp 56 is now the impedance of capacitor 62 plus resistor 64, in parallel with resistor 78 plus resistors 74 + 72 divided by the previous quantity. At this frequency of

120 Hz, the gain stops rising and levels off at a gain of about 16dB minus the input attenuation of 6dB.

As the audio frequency becomes higher, the reactance of capacitor 58 starts to change and come into importance. The frequency where impedance of capacitor 58 equals the parallel combination of the set of 3R resistors at node 63 coupling signal to resistor 60, is approximately 2.9 KHz. This is the frequency at which a high frequency rolloff occurs. After another decade of frequency rise, the reactance of capacitor 58 is low and the curve flattens out to zero dB.

#### COMBINING/MATRIXING THE (L-R) AND (L+R) SIGNALS

The (L-R) signal path provides the expansion function that is heard by the listener. The rising midrange of (L-R) provides the out-of-phase frequencies at the left and right ears at the appropriate wavelengths that psychoacoustically produce the directional cues for the perception of the direction from which the sound originates. According to aspects of the present invention, the (L+R) frequency response provides a compensating frequency response, which may or may not be complimentary to the frequency response of the (L-R) signal path and tends to make the overall frequency response flatter when summed with the signal of the (L-R) channel.

The (L-R) signal at node 73 is added to the (L+R) signal at node 75, through respective resistors 4R for producing the L signal at node 80. The (L-R) signal at node 73 is amplified by opamp 74 which according to the  $5(2)R$  (a value of 2 times R) feedback resistor to resistor 5R provides an amplification of two, which when added through its resistor 6R to (L+R) through resistor 6R provides the R signal at node 76.

Stereo expansion is provided by making the difference signal larger than the sum signal. The amount of larger (L-R) signal is determined by listening because it involves a psychoacoustic interpretation by the brain of what both ears are hearing. If an A/B comparison is done, most people will start hearing expansion as soon as the (L-R) is boosted one or two dB relative to the (L+R) signal.

Stereo image expansion appears to work better if the difference signal boost is confined to the midrange frequencies. However, this results in the unwanted artifacts discussed earlier. To compensate for such artifacts, according to aspects of the present invention, the compensating frequency response in the (L+R) signal is provided.

Optimization can be accomplished by listening to a variety of program material to determine that: (1) A significant amount of expansion is heard for most stereo program material, both music and movie, and (2) There is no excessive masking of spoken/sung vocals. This usually means that the amount of the expansion (L-R) signal is larger by between 3 and 10 dB. This can be accomplished by increasing the gain of the opamps 56, 74 in the (L-R) signal path. For item (2) above, treble boost of the (L + R) signal restores lost sibilants resulting in greater intelligibility.

As opposed to the prior art of Fig. 1 wherein the sum and difference signals are irretrievably mixed together in providing the stereophonic expansion, the active matrix type circuit of the present invention has the advantage of isolating the sum signal from the difference signal while still providing stereophonic spatial expansion. This makes it easy to make the amplitude and frequency response changes in both sum and difference signals to optimize the spatial expansion response, e.g., change relative tonal compensations and gains. The active matrixing amplifiers can be considered to be arranged in seriatum, which means that the output of one matrixing amplifier is coupled to the input of another matrixing amplifier.

**WHAT IS CLAIMED**

1. A stereophonic expansion circuit having (L+R) and (L-R) signal paths, comprising;

means for processing (L+R) and (L-R) stereo signals, and

means for tonal compensation of the (L+R) signal.

2. The stereophonic expansion circuit of claim 1 wherein the tonal compensation of the (L+R) signal is in the bass and/or treble frequency bands.

3. The stereophonic expansion circuit of claim 1 wherein the (L+R) signal is tonally compensated to reduce the mid-range frequency signals.

4. The stereophonic expansion circuit of claim 2 wherein the (L+R) signal is tonally compensated to be complementary to a frequency curve of the (L-R) signal.

5. The stereophonic expansion circuit of claim 1 wherein the tonal compensation can be switched between "ON" and "OFF" modes.

6. The stereophonic expansion circuit of claim 5 wherein the tonal compensation is switched "OFF" when stereo expansion is switched "OFF".

7. The stereophonic expansion circuit of claim 1 wherein a switchable gain boost is provided in an (L-R) signal path.

8. The stereophonic expansion circuit of claim 7 wherein the gain boost is switched "OFF" when tonal compensation is switched "OFF".

9. The stereophonic expansion circuit of claim 1 wherein the tonal compensation of the (L+R) signal is with respect to the (L-R) signal.

10. A stereophonic expansion circuit having an (L+R) and (L-R) signal paths wherein the tonal compensation of the (L+R) signal path is approximately complementary to the tonal frequency response of the (L-R) signal path.

11. The stereophonic expansion circuit of claim 10 wherein tonal compensation is switchable between "ON" and "OFF" modes.

12. The stereophonic expansion circuit of claim 11 wherein the complementary tonal compensation is switched "OFF" when the stereo expansion is switched "OFF".

13. The stereophonic expansion circuit of claim 12 wherein a switched gain boost is provided in an (L-R) signal path.

14. The stereophonic expansion circuit of claim 13 wherein the gain boost is switched "OFF" when the tonal compensation is switched "OFF".

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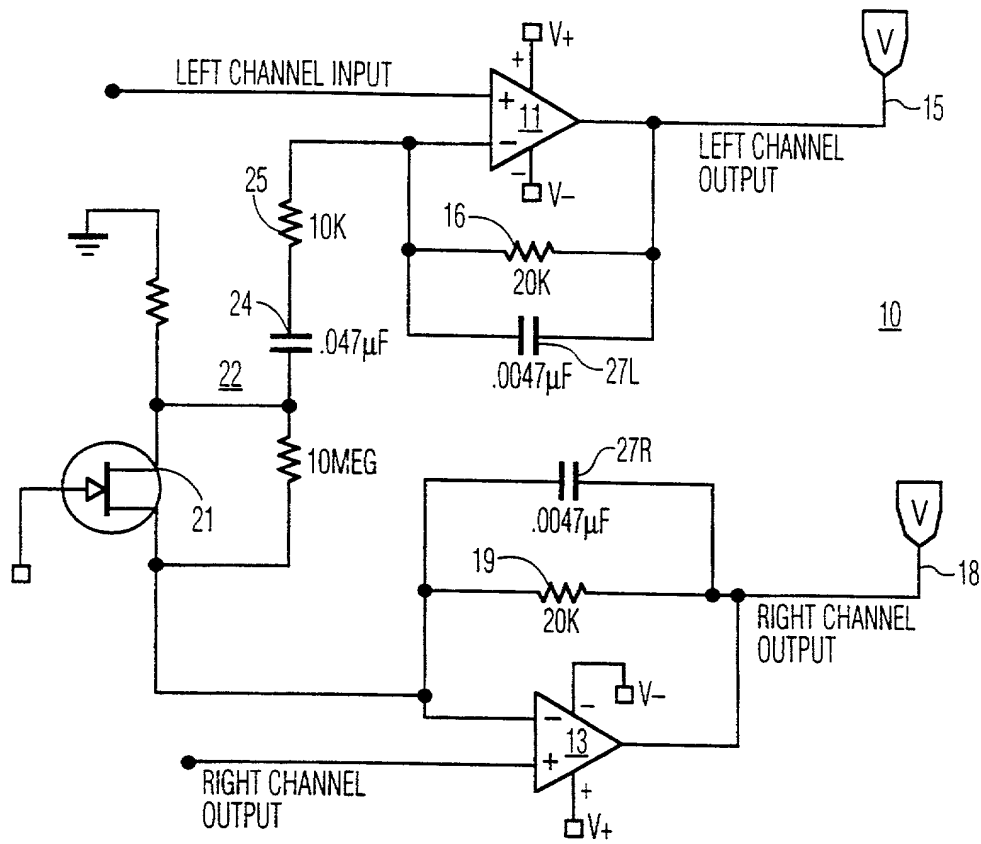


FIG. 1



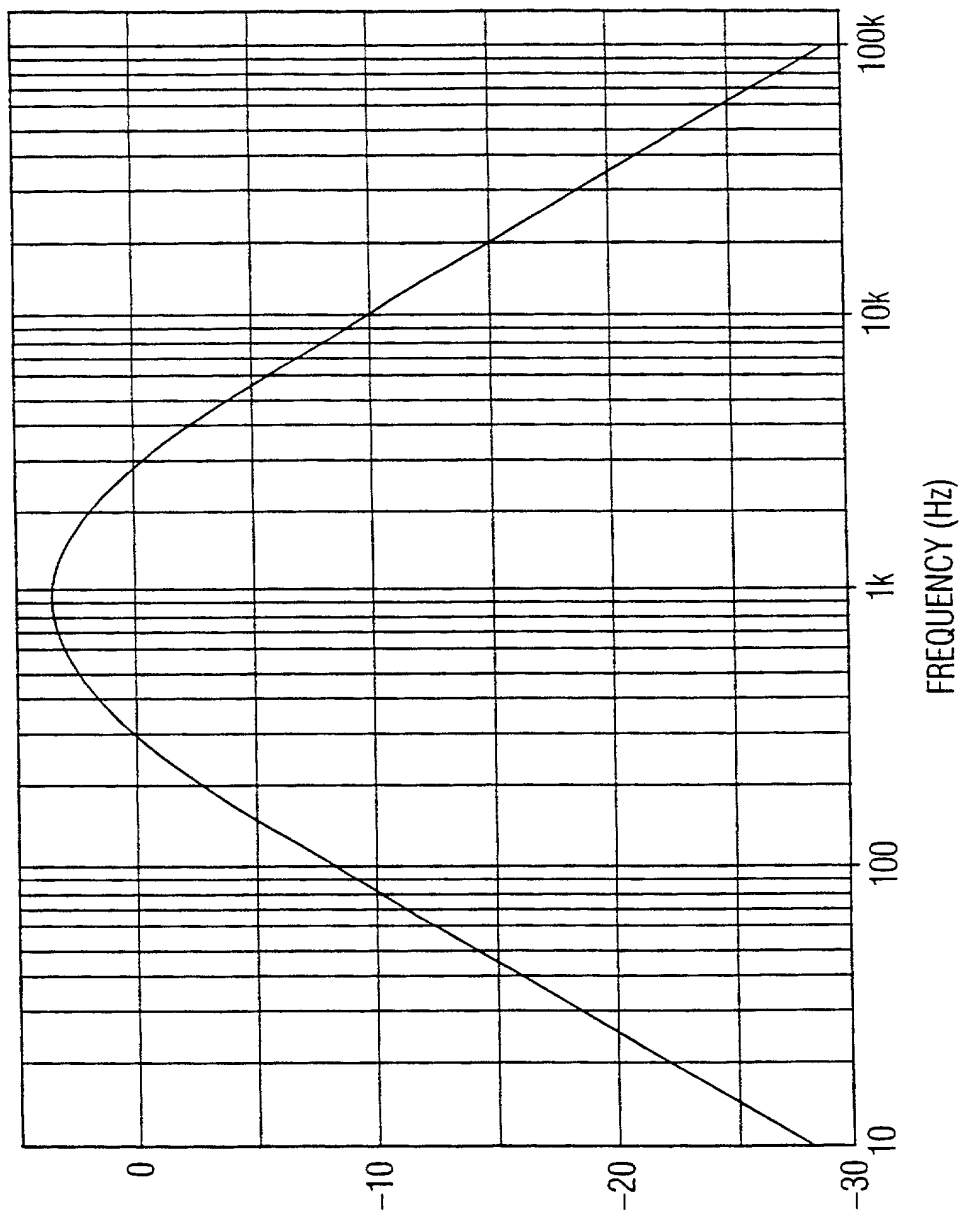


FIG. 2

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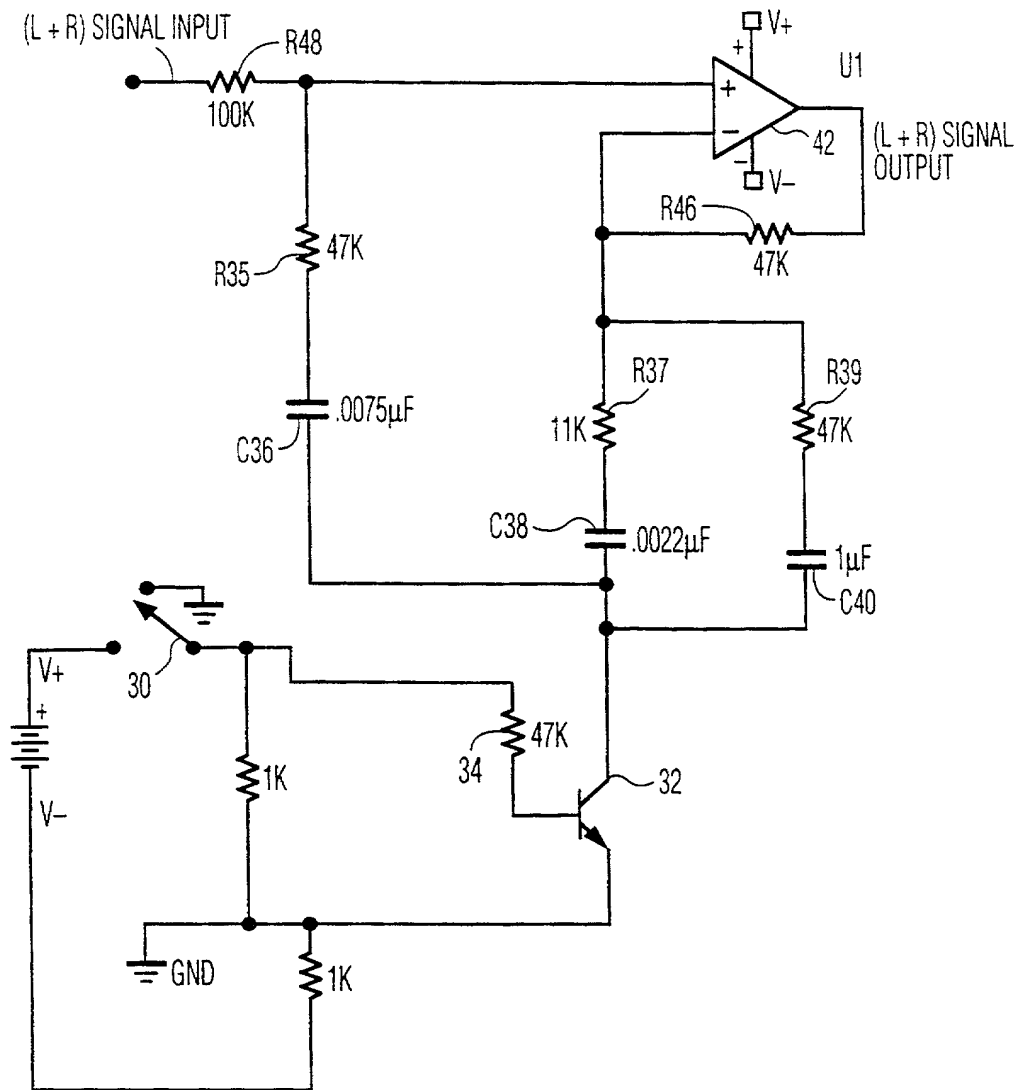
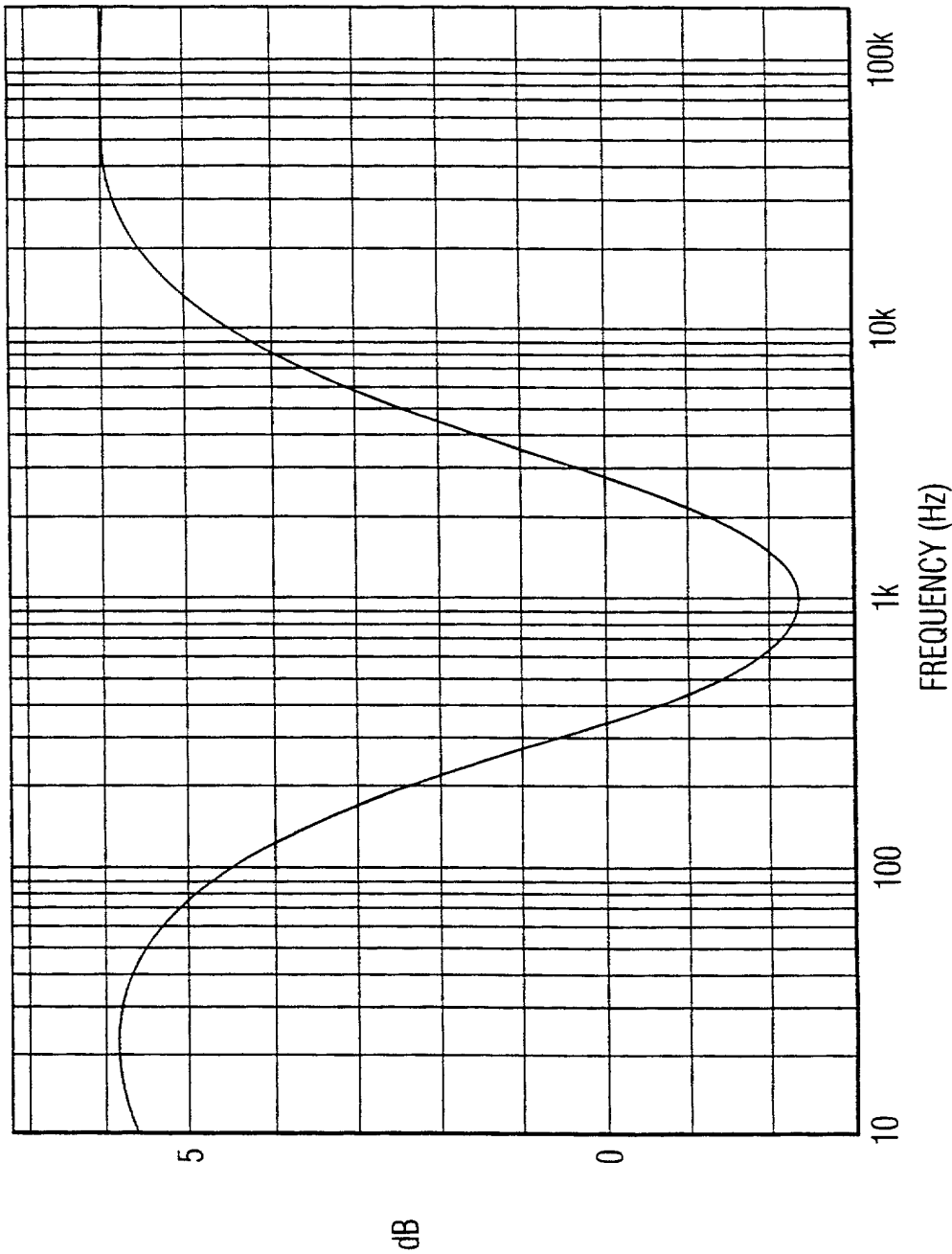
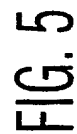


FIG. 3

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FIG. 4





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<b>DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION</b> (37 CFR 1.63)	<b>Attorney Docket Number</b>	RCA 89855
	<b>First Named Inventor</b>	Alan Anderson Hoover
	<b>COMPLETE IF KNOWN</b>	
	<b>Application Number</b>	/
	<b>Filing Date</b>	
	<b>Group Art Unit</b>	
<input checked="" type="checkbox"/> Declaration Submitted with Initial Filing	OR	<input type="checkbox"/> Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16(e)))
	<b>Examiner Name</b>	

As a below named inventor, I hereby declare that:

My residence, mailing address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

**A STEREOPHONIC SPATIAL EXPANSION CIRCUIT WITH TONAL COMPENSATION AND ACTIVE MATRIXING**

the specification of which

(Title of the Invention)

☐ is attached hereto

OR

☒ was filed on

December 15, 1999

as United States Application Number or PCT International

Application Number **PCT/US99/29939** and was amended on (MM/DD/YYYY) (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above:

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign	Foreign Filing Date	Priority	Certified Copy Attached?
			YES NO
		<input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto:

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YYYY)	
US 60/115,324	January 11, 1999	<input type="checkbox"/> Additional provisional application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

[Page 1 of 2]

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## DECLARATION — Utility or Design Patent Application

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NAME OF SOLE OR FIRST INVENTOR :

☐ A petition has been filed for this unsigned inventor

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Family Name  
or Surname HOOVER

Inventor's  
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Residence: City

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☐ Additional inventors are being named on \_\_\_\_\_ supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto.